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Title: The Effect of Income on Demand for Micronutrients in Poor Rural Mexico

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The Effect of Income on Demand for Micronutrients in Poor Rural Mexico

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Abstract

We estimate income elasticities for a variety of macro- and micro-nutrients using a sample of poor rural households in Mexico. The nutrient-income elasticity is estimated using a linear regression model controlling both for the clustered nature of our data and for the bias due to measurement error in nutrient consumption at the household level. Our preferred estimates (instrumental variable-fixed effect specification for the sample of all households) show a sizeable positive elasticity for some nutrients (especially vitamin A 0.8, vitamin C 0.69 and calcium 0.45). For other nutrients the effect of income on the consumption is still significant but very small (elasticity for fiber is only 0.09 and for iron 0.08). We also test for the robustness of our estimates using a semi-parametric estimator (partially linear model) and whether the presence of zero consumption for specific micronutrients in our sample, such as cholesterol and heme iron, can be a source of bias for our estimates.

JEL classification: *012; C14*
Keywords: vitamin A , vitamin C; folate; iron; zinc; calcium; calories; protein; fat; carbohydrates; Income elasticity; partially linear model.

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The Effect of Income on Demand for Micronutrients in Poor Rural Mexico

1. Introduction

Deficiencies in micronutrients--such as iron, zinc, vitamins A and C, and iodine--are increasingly recognized as an important nutrition problem that affects millions of children and adults in the developing world. The consequences of child malnutrition during the preschool period have been studied extensively (Beaton, et al., 1993, Bhutta, et al., 1999, Bleichrodt and Born 1994, Lozoff and Wachs 2000, Pelletier, Frongillo and Habicht 1993, Pelletier, et al., 1995, Rose, Martorell and Rivera 1992, Wachs 1995). It is estimated that about half of all deaths in developing countries in children less than five years of age are due to the interaction between malnutrition and common infections such as diarrheal diseases, respiratory infections and measles. These infections kill children easily only in the presence of malnutrition, which impairs immune function and lowers resistance to infections. Two micronutrient deficiencies, iodine deficiency and anemia, have been shown to be important causes of poor cognitive development, particularly when they affect children under two years of age (e.g. Horton and Ross, 2003).

In view of the negative consequences of a diet poor in micronutrients, the potential of social programs to improve the nutrition of vulnerable populations is of particular concern to policy makers. The interventions available for resolving micronutrient deficiencies range from multiple micronutrient supplementation in young children, which are more useful in the short-run, to food fortification and diet diversification that are more effective in the long-run. This paper contributes in this area by providing estimates of the extent to which micronutrient consumption at the household level responds to increases in household income. Cash transfer programs, frequently combined with conditions on some specific behavior such as attending nutrition workshops and regular visits to health centers, provide an increasingly popular approach towards alleviating poverty and malnutrition.[1] The income elasticity for a specific micronutrient, the parameter that summarizes the percentage change in the consumption of a specific micronutrient corresponding to a one percent change in household income, is critical to understanding one of the key determinants of consumption of micronutrients. As household income increases, households may change the composition of their food consumption, and thus their micronutrient intake. If increases in income result in changes in the diet of households, towards foods with higher micronutrient content (for example, eating more vegetables/fruits and meat), then micronutrient deficiencies may fall.

In much of the economic development literature nutrition problems are practically synonymous to the inadequacy of energy as measured by the availability or consumption of calories (Subramanian and Deaton, 1996; Strauss and Thomas, 1995, 1998). Unfortunately, irrespective of the size of the estimated income elasticity for calories, there is nothing that can be inferred about the consumption of essential micronutrients. A significantly positive relationship between calories and income does not necessarily imply a higher consumption of micronutrients since a higher income may simply result in households buying food items with a higher caloric content, but not higher micronutrient content. A similar argument applies when the income elasticity for calories is very small or zero. When household income decreases, household calories

[1] The *Oportunidades* program of the Mexican government is one such program aimed at increasing the investments of poor households in human capital.

may be maintained more or less constant through substitutions within and between food groups while the consumption of essential micronutrients may decrease dramatically as households consume less meat, vegetables, eggs and milk.

Thus, even though there is an abundance of estimates on the income elasticity for calories, empirical evidence on the micronutrient income elasticity is relatively scarce (Behrman, 1995). In addition, the evidence that does exist suggests substantial differences in micronutrient-income elasticities (e.g. Behrman and Deolalikar, 1987; Bouis, 1991). In Indonesia, for example, Pitt and Rosenzweig (1985), using data from farm households report very low nutrient-income elasticities (below 0.03) for many of the same nutrients considered in the present study (i.e., calories, protein, fat, carbohydrates, calcium, iron, vitamin A, and vitamin C). Another study using data from rural and urban areas in Indonesia reports much higher nutrient income elasticities (for example, from 0.70 to 1.20 for the lower 40 percent of the population by expenditure on Java (Chernichovsky and Meesook, 1984). Similarly diverse estimates are reported for other countries. Behrman and Deolalikar, (1987), for example, using data from ICRISAT report income elasticity estimates of 0.06 to 0.19 for protein (depending on whether level estimates or differences over time are used), 0.30 to –0.22 for calcium, -0.11 to 0.30 for iron, 0.19 to 2.01 for carotene, -0.08 to 0.18 for thiamine, 0.69 to 0.01 for riboflavin, -0.15 to 0.21 for niacin, and 0.15 to 1.25 for ascorbic acid. The Nicaraguan study (Behrman and Wolfe, 1987) reports significant income elasticity estimates in the range of 0.04 to 0.11 for calories, protein, iron, and vitamin A (with statistically significant, but quantitatively small, nonlinearities). The Philippine study (Bouis, 1991) reports an iron-income elasticity of 0.44, a calorie income elasticity of 0.16, and insignificant income elasticities for vitamin A and vitamin C. To date, to our knowledge, there are no estimates of the income elasticity for micronutrient in Mexico.

The objective of this paper is to provide some of the first estimates of the income elasticity for key micronutrients in Mexico, such as vitamin A and C, folate, iron, zinc and calcium as well as for energy (kcal), and all the macronutrients (protein, saturated, monounsaturated and polyunsaturated fat, and carbohydrates). Given that the consumption of fiber can inhibit the absorption of some essential micronutrients, such a zinc and iron, we also examine the income elasticity for dietary fiber. Reliable elasticity estimates can help policy makers determine *ex-ante* whether a cash transfer program, and/or economic growth per se can be at all effective at increasing micronutrient consumption among poor households or whether different interventions altogether may be needed. Considering the frequency at which poor rural areas in Mexico are affected by natural disasters such as floods, it is also useful to know how effective cash transfers could be as an instrument for maintaining (if not improving) the nutritional status of affected households.

The study of the micronutrient consumption patterns and the relationship between micronutrients and income are particularly important for Mexico. On the one hand, the 1999 National Nutrition Survey of Mexico identifies zinc and iron deficiency as a major nutritional problem in Mexican children (Barquera et al., 2003a). On the other hand, Mexico, like a number of developing countries during the last fifteen years, appears to be experiencing important reductions in the prevalence of infections and undernourishment, accompanied by large increases in the incidence of chronic diseases and overnourishment (Rivera et al. 2002, Bobadilla et al. 1993; Frenk et al. 1991, Popkin, 1994;, Drewnoski and Popkin, 1997; Murphy et al., 1992; and Zeitlin, Ghassemi and Mansour, 1990). In such a context, it is critical to have a better understanding of the effects of increases in household income on the composition of household diet, in general, and the consumption of micronutrients in particular.

In line with the recent trend in the literature on the calorie income elasticity, our study places particular emphasis on the sensitivity of the elasticity estimates. Our econometric methodology consists of both a linear regression and a semi-parametric approach. The regression approach imposes a linear relationship between micronutrient consumption and income, which in turn results in a micronutrient income elasticity that is constant and independent of the level of income but allows us to control for biases due to measurement error in consumption.[2] The semi-parametric approach allows the income elasticity for micronutrients to vary in the most flexible manner possible with the level of household income. In addition to this, we try to explore whether the presence of zero consumption for specific micronutrients in our sample can be a source of bias for the estimates.

The rest of the paper is organized as follows. Section 2 describes in more detail the data used and discusses some descriptive evidence on the nutrient consumption in the sample. Section 3 presents and discusses the results from the linear regression approach. Section 4 illustrates the semi-parametric approach that we employ to analyze the functional shape of the relationship between micronutrients and income and explores the zero consumption issue. In section 5, we sum up our results and draw some concluding remarks.

[2] Recent published studies include Gibson and Rozelle (2002), Abdulai and Aubert (2004), and Skoufias (2003).

2. Data and Macro and Micro-Nutrient consumption patterns

The data we use is based on a sample of 7553 households in 240 poor rural localities from eight Mexican states (Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz and Yucatan), surveyed between October 2003 and April 2004 . This sample has been collected for the purposes of evaluating the *Programa de Apoyo Alimentario* (PAL). [3] This program has as its major objective the improvement of the nutritional status of poor households living in rural localities of Mexico and it is targeted to localities that are not covered by other food programs, or programs with a substantial nutrition component, such as *Oportunidades* and *Abasto Social de Leche*. [4] In order to be incorporated into the program the localities have to meet some requirements such as having a population of less than 2500, having at least one household with a poor nutritional status (according to the criterions established by SEDESOL, *Secretaria de Desarrollo Social*, that is the social development arm of the Mexican government), being accessible (not more than 2.5km from a road), and close enough (not more than 2.5 km) to a DICONSA[5] store.

The support provided is either in-kind transfers (value of food provided is of 150 pesos) or cash transfer of 150 pesos according to what the program administrators think it is the more appropriate in the specific case. While the major component of the program is food support, other complementary operations are being provided, such as health assistance, nutritional education classes and support to build floors and latrines.

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[3] Since one of the purposes of the evaluation of PAL is studying is impact on the nutrition of children of age less than 5, it was decided from the beginning that 40% of households interviewed in each locality had to have children less than 5.
[4] For instance, the localities that do not fulfill the requirements in terms of education and health infrastructures in order to be included in *Oportunidades* can be included in PAL.
[5] DICONSA is the Mexican government's agency that manages the supply of food (through its stores) to rural and marginalized localities.

The analysis in this paper is based on the baseline survey round that took place before the start of the program. The micronutrient income elasticity estimates derived here can thus serve as benchmark estimates for the impact of the cash component of the program on micronutrient consumption at the household level. The survey collects extensive socioeconomic information, as well as information about food and non food expenditures. Specifically, the consumption module collects information on the quantity consumed (including that out of own production) in the last seven days for sixty one food items.[6]

In much of the development literature estimates of the demand for nutrients are typically derived through an indirect approach. Since consumption of micronutrients is determined by what foods and how much of those foods are consumed, good estimates of the demand system parameters for food can be used, by applying nutrient-to-food conversion factors (Pitt, 1983, Strauss, 1984). However, for such an indirect procedure to lead to good estimates of the demand for micronutrients, the estimates of the food demand system must be good in a variety of respects. Similarly, deriving direct estimates of nutrient demand, it is important to use food groups that are not aggregated "too much" or else important within food group substitutions may be missed. For example, Behrman and Deolalikar (1987) suggest that the indirect approach of estimating systems of demand for food groups with food groups being fairly broad aggregates of individual foods, may lead to nutrient income elasticities that are considerably biased (Subramanian and Deaton, 1996).

[6] We did not use the information collected on purchases of food, as this would provide information on nutrient availability instead of consumption. The PAL questionnaire also contains a module based on the alternative approach of measuring food consumption through a 24 hour recall survey, whereby respondents are asked to recall all the foods consumed by each household member during the previous day.

Mindful of these considerations we adopt a flexible approach that simply examines the total consumption of major nutrients in rural poor households in Mexico by aggregating the nutrient contents of the sixty one food items contained in the PAL survey. We use a food composition database compiled by the National Institute of Public Health of Mexico (INSP) that contains information on the macro- and micronutrient content per 100 grams of all the major food items in Mexico to convert the quantity consumed of each of the sixty one food items by each household into its equivalent content of calories, protein, fat, carbohydrates, and micronutrients. The quantity of each nutrient consumed is then aggregated at the household level.

In order to shed some light on the nutrient consumption patterns in our sample, it is useful to conduct a descriptive analysis of nutrient consumption. This offers a *status quo* picture of macro and micronutrient consumption. The behavior-related issues, such as the response of nutrient consumption to changes in income are discussed in the next section.

Table 1

Table 1 reports some descriptive statistics (mean, median and interquartile range) for a list of macronutrients and major micronutrients (fiber, protein, fat, cholesterol, saturated, monounsaturated and polyunsaturated fat, carbohydrates, vitamin A and C, folate, iron and heme iron, zinc and calcium). These descriptive statistics and all the estimations below are computed on a sample that excludes households with a value of per capita caloric consumption that is extremely low (<500 kcal) or extremely high (>4500 kcal). Iron is of particular interest since iron deficiency determines to a large degree the prevalence of anemia, so widely present in Mexico. (see Barquera et al., 2003a). Inorganic (or nonheme) iron is a mineral widely present in relatively inexpensive foods such as beans and spinach. Mexican diets are very rich in nonheme iron, but the quality of it is poor, so nutrient absorption is poor. Heme iron, on the other hand, has a much better absorption rate, but its sources are animal-products, which are expensive. More importantly, it is the lack of heme iron that determines the prevalence of anemia. We present separate results for heme iron since findings for this nutrient are much better understood and applied (than those for total iron).

Since one of our main purposes is to study whether nutrient consumption changes between poorer and richer households we present the statistics for three groups of households: all households, households at the bottom 25% of the distribution of per capita expenditure (PCE), and households at the top 25% of PCE. We use PCE, and not current income as a measure of household welfare and income because, in general, current expenditure and consumption tend to be a more reliable estimate of a household's permanent income than current income. PCE is derived by dividing total food and nonfood expenditures by household size. Total household expenditure (per month) is defined as the sum of value of food consumption, value of meals consumed away from home and total expenditure for goods other than food (excluding expenditures on health services). Deaton and Zaidi (2002) stress that in cases in which the amount of food consumed can be distinguished from food purchased (as is the case with our data), it is the value of food consumed that should go into the consumption aggregate. The value of food consumed at home is constructed, following the guidelines above, using the quantity of food consumed at home and expressing it in monthly value using as prices the median unit value for each food at the locality level[7].

[7] We also have the information of the market price for the food items at the locality level. However, we do not have the market price for all the food items that are included in the list of

One general pattern that is obvious in table 1 is that the value for the mean is bigger than the median value for all the nutrients considered here. This means that the distribution of each nutrient is positively skewed rather than symmetric and that considering only the mean would lead to an overestimation of nutrient consumption. For this reason we also present the interquartile difference (IQ=Q75-Q25) as a measure of the standard deviation in the consumption of nutrients. Both the median and the interquartile range are better summaries of a distribution when the data are skewed or contain outliers. Another remarkable finding is the difference between the consumption for the top 25% PCE and the bottom 25% PCE population (for example, the top 25% PCE households displays a calorie consumption that is 64% bigger than the bottom 25% PCE group; the comparison for calcium is even more striking since the top 25% PCE population's consumption is around four times bigger than the bottom 25% PCE's). Iron and heme (blood) iron present a contrasting pattern: while top 25% PCE's consumption for total iron is only around 1.2 times bigger than bottom 25%'s, the proportion is around 6.5 times when it comes to heme iron. These descriptive results are a first indication that nutrient consumption depends heavily on changes in income, even in a sample of households which overall is quite poor and by first appearances not very heterogeneous.

One implication of this result is that on average households in the top 25% group could have a nutrient consumption adequacy[8] above 100% while those in the bottom 25%'s could be far below 100% with this completely differentiating the possible

foods consumed (either some items are not included in the market price list or the definition of the food item is different).

[8] The nutrient intake adequacy is typically expressed as the ratio between the household's nutrient consumption and an appropriate reference intake.

interventions to be designed for the two groups.

3. Nutrient – Income Elasticity

We begin by estimating the nutrient-income elasticity with a linear regression approach. Some of the benefits of the linear regression model include the ability to control for village-specific fixed effects and for possible bias due to measurement error in nutrient consumption at the household level. The cost, on the other hand, is the fact that the conditional relationship between micronutrient and income is assumed to be linear. The non linearity of the relationship between nutrient consumption and income and the presence of households with zero consumption for some nutrients is explored in the following section.

For each nutrient, we estimate a linear regressions of the form:

$$\ln NUT_{i,v} = \alpha_0 + \alpha_1 FE_v + \beta Z_{i,v} + \gamma \ln PCE_{i,v} + \varepsilon_{i,v} \tag{1}$$

where NUT is per capita nutrient consumption in household i in locality v, FE is a vector of binary variables summarizing village-specific fixed effects, Z is a vector of household characteristics and ε is an error term.

The inclusion of locality-specific fixed effects, FE, is intended to control for price differences across villages and other village-specific characteristics that may have also a direct impact on nutrient consumption. The vector Z includes age-sex household composition ratios, age and educational level of the household head and of his/her spouse, number of individuals within the household with access to health services, binary variables for ownership of assets (radio and television) and binary variables indicating whether the household head and his/her spouse speak an indigenous language.[9]

FE-OLS estimates

The results of the OLS estimation of (1) are presented in table 2 (in the columns labeled "FE-OLS"). One clear pattern that emerges is that the estimated elasticities for the sample of all households are all positive, quite high and significant for all macro and micronutrients. The calorie income elasticity is 0.46, remarkably similar to 0.35 calorie income elasticity estimate of Subramanian and Deaton (1996) for India, and the 0.43 estimate of Skoufias (2003) for Indonesia. The micronutrients with the highest income elasticity are vitamin A (1.22) and vitamin C (1.06). Thus a 1 % increase in income is likely to result in an increase of more than 1% in the consumption of vitamins A and C. These estimates are much higher than the income elasticities reported by Pitt and Rosenzweig (1985) for the same micronutrients.[10] One possible explanation for the lower elasticity estimates obtained by these authors is the fact that nutrient conversion factors were applied at twelve aggregated food groups rather at the individual food item level as in this study. As Pitt and Rosenzweig (1985) acknowledge, this approach may be responsible for their low elasticity estimates since it ignores possible substitutions within food groups.

Among the micronutrients examined, calcium has the next highest income elasticity of 0.77. The income elasticity for iron, folate, and zinc ranges from 0.344 (iron) to 0.44 (zinc).

Table 2

[9] A description of the full set of variables along with their key descriptive statistics (mean and standard deviation) is contained in Appendix A.
[10] Their profit elasticity estimates are 0.0245 and 0.0274 for vitamins A and C, respectively.

FE-IV estimates

In this study the measurement of nutrient consumption is done by converting food quantities into nutrient avilability using food composition tables. While this method has the advantage of being easily implemented, it suffers from several potentially important sources of systematic bias. Major drawbacks are that this method assumes that no food is wasted (and this will cause problems in case very low-income households waste less than those that are better off), does not take into account explicitly meals given to guests or employees and meals received in-kind (however, this issue can be addressed if the survey collects information about it) and meals taken away from home (this can be a source of bias since, for example, it is not necessarily true that meals taken away from home have the same caloric consumption of meals eaten at home).

Accordingly, it is likely that measurement error in nutrient consumption will be correlated with PCE, with this being a source of bias in estimates of nutrient-PCE elasticities. In particular, as first noted by Bouis and Haddad (1992), the possibility that measurement errors in nutrient consumption are likely to be positively correlated with measurement errors in household consumption implies that this type of measurement error is not the classical errors-in-variables problem where coefficients are likely to be biased towards zero (attenuation bias). In the context of correlated measurement errors in the dependent and independent variables of a regression, the upward bias from the correlated errors will typically outweigh the standard downward attenuation bias from the measurement error in total consumption, leaving a net upward bias in income elasticity estimates obtained using OLS methods. These are the reasons behind our choice of estimating (1) also with an instrumental variable (IV) approach. In particular, we estimate a fixed effect IV model in which we maintain the village-specific effects in the specification and we instrument *lnPCE* with the following variables: log per capita non food expenditure, material of the house's floor, walls and roof, dummies for the presence of kitchen, electricity, fridge and heater in the house, and type of toilet.

The results of the fixed effect IV estimation are also reported in table 2 (see columns labeled "FE-IV")[11]. The estimated elasticities for the sample all households are positive and significant for all nutrients. However, the FE-IV estimates are lower than the FE-OLS, a pattern that is consistent with arguments presented earlier that the FE-OLS estimates are biased upward. However, the elasticities for vitamins continue to have a remarkably high value (0.8 for vitamin A and 0.69 for vitamin C). For some nutrients, the difference between FE-OLS and FE-IV estimate is quite large. For example, the fiber-income elasticity is 0.33 in the FE-OLS specification and only 0.091 in the FE-IV, while the income elasticity for iron drops from 0.344 (FE-OLS) to 0.077 (FE-IV).

4. Checking the Robustness of the Nutrient –Income Elasticity Estimates

Two potentially important issues are neglected by the linear regression approach above: non linearity of the relationship between nutrient consumption and income and the presence of households with zero consumption for some nutrients.

We explore potential nonlinearities in the relationship between nutrients and income in two different ways: first, we re-estimate equation (1) using FE-OLS and FE-IV separately for the sample of households below and above the median PCE; second, we re-estimate the relationship between nutrient consumption and income with a semi-parametric approach. The presence of households with zero consumption for some nutrients is analyzed in more detail by investigating the determinants of zero

[11] In appendix B the first-stage regression results for the 2SLS estimation (sample all households) are reported.

consumption and by estimating elasticities with methods that do take into account the censoring at zero of the values of micronutrient consumption.

Nonlinearity of the nutrient-income relationship

The FE-OLS and FE-IV estimates for the sample of households below and above the median PCE are also presented in Table 2. Using FE-OLS, the income elasticities in the sample below the median are always higher the income elasticities above the median. Major drops in elasticities are for vitamins, even though they remain high also above the median of PCE. It is not easy to compare and contrast these results with previous work since there is only scarce evidence on the micronutrient income elasticity and the estimates suggests substantial difference in elasticities. [12]

The patterns observed with the FE-IV method applied to the samples below and above the median of PCE are more difficult to interpret. Below the median of PCE and only for some nutrients (fats, cholesterol, vitamins and calcium) we find a confirmation of the behavior we observed for the sample all households: the IV estimates are positive and significant but much smaller in value than the fixed effect's. This is in contrast with the pattern displayed by the IV estimates for the sample of households above the median of PCE, since IV coefficients are all negative (and only some of them are significant) while the fixed effect's are all positive and significant. However, it has to be noticed that the assumption of a linear specification is particularly problematic for the sample of households above the median of PCE, (this point is analyzed more extensively

[12] Among previous work we mention Behrman and Deolalikar (1987) that using data from ICRISAT report elasticity estimates of 0.06 to 0.19 for protein, 0.30 to -0.22 for calcium, -0.11 to 0.30 for iron (depending on whether level estimates or differences over time are used); Behrman and Wolfe (1987) study Nicaragua and find elasticities in the range 0.04 to 0.11 for calories, protein, iron and vitamin A; Bouis (1991) reports an iron-income elasticity of 0.44, a calorie-income's of 0.16 and insignificant elasticities for vitamin A and C.

in the next section), with this suggesting that the results of the IV estimation for the sample above the median are less reliable than those for the other samples considered.

A semi-parametric approach is useful for identifying the functional form that best describes the relationship between nutrient and income. The model we estimate below is a partially linear model:

$$y_i = z_i \beta + m(x_i) + \varepsilon_i \qquad (2)$$

where y_i denotes the *ln* of the quantity consumed of any given nutrient, z_i is a vector of the variables that we would like to control for in a linear function, β is a vector of parameters and *m(x)* is a nonlinear function of x in this case of the lnPCE.

This model has been traditionally estimated with the Robinson (1988) estimator, which is especially suitable for the estimation of the vector β in (2). Since we are primarily interested in the estimation of *m(x)* we implement an estimator based on a differencing approach (first suggested by Yatchew, 1997, and discussed by DiNardo and Tobias, 2001). The procedure for estimating (2) consists of the following steps: first, the data are sorted by ascending values of the x variable (in our case *ln*PCE) and the *m*-th order[13] differences are calculated on the sorted data. The idea here is that if x_i and x_{i-1} are close enough in the sorted data, then so will $m(x_i)$ and $m(x_{i-1})$. Accordingly, the differenced version of the model (2) on the sorted data will remove the nonparametric component $m(x_i)$. Then the vector β can be estimated with a regression of the differenced y's on the differenced z's. With the estimated vector $\hat{\beta}$ in hand it is then

[13] As noted in Yatchew (1997) the differencing order is important as far as the efficiency of the estimator is concerned. In order to maximize the efficiency of the estimator, we use the optimal differencing weights, as tabulated in Yatchew (1997), to compute differences of the sorted data. We set the differencing order to 3 to compute differences in the semi-parametric estimation. We also tried other differencing orders and the results did not change substantially.

possible to derive a new “adjusted” dependent variable net of the linear effect of the z variables, i.e.,

$$y_{adjusted} = y_i - z_i\hat{\beta} \tag{3}$$

The final step is to perform a local linear regression using the variable defined in (3) as dependent variable. In particular, we use a smooth local regression technique similar to that used by Subramianan and Deaton (1996). Their procedure works as follows. At any given point of x, we run a weighted linear regression of the logarithm of the dependent variable $y_{adjusted}$ on *lnPCE*. The weights are chosen to be largest for sample points close to *x* and to diminish with distance from *x*; they are also set so that, as the sample size increases, the weight given to the immediate neighborhood of *x* is increased so that, in the limit, only *x* is represented. In our case, for the local regression at *x*, observation *i* gets the (quartic kernel) weight

$$w_i(x) = \frac{15}{16}\left[1 - \left(\frac{x - x_i}{h}\right)^2\right]^2 \tag{4}$$

if $-h \le x - x_i \le h$ and zero otherwise. The quantity *h* is a bandwidth that is set so as to trade off bias and variance (in general a small bandwidth brings smaller variance but higher bias while a large *h* determines a small bias but higher variance). Our main objective is to plot the regression function and its slope so that, instead of calculating local regressions for each point in the sample, we use an evenly spaced grid of 60 points in the distribution of *lnPCE* and calculate a local regression for each grid. The estimate of *m(x)* is the predicted value from the local regression at *x*, while the local estimated slope coefficient provides an estimate of the slope *m′(x)*. Given that both *y* and *x* are expressed in log form, the derivative of the regression function, *m′(x)*, is an estimate of the elasticity of the demand for nutrients with respect to income. Then a graph of the nutrient-income elasticity estimate against the level of (log) income allows one to determine easily the extent to which the elasticity varies with income. The bandwidth h for the quartic kernel weight is set to 0.5 after inspection of alternative plots. This value for h seems to be appropriate with respect to the trade off between bias and variance of the estimated regression function.

The results of the semi-parametric estimation of the relationship between nutrients and *lnPCE* are presented and discussed here. The vector z in eq. (2) includes the age and gender composition of the household expressed as ratios of the total family size. Specifically, the age and gender groups are males and females between age 0 to 4, 5 to 9, 10 to 14, 15 to 54 and more than 55.

Figure 1

Figure 1 shows the estimated functions that link the nutrients (we use the same list as in table 1) and the *lnPCE* (see left panels) as well as the elasticity between nutrient consumption and PCE (see right panels). The plots in the left panels of figure 1 suggest that a linear form is a good description of the relationship between nutrient and PCE around the median of *lnPCE* with this being generally true for all the nutrient vs. *lnPCE* estimated functions. Two main patterns seem to be prevalent in the income elasticity of nutrients (i.e. the slope of the estimated regression functions). Below the median of PCE the income elasticity is either decreasing or constant. Above the median the income is decreasing for all the nutrients and it seems that it falls faster for very high levels of

PCE.[14] Another major difference regarding the behavior of the income elasticity slope below the median of PCE is that for some nutrients (energy, fiber, protein, folate, calcium and zinc) the slope is more or less constant or fluctuating within a limited range; for other nutrients such as fats, carbohydrates, vitamins and iron, the elasticity is decreasing below the median of PCE but at a rate that is smaller than the one at high values of PCE.

Zero nutrient consumption

Some nutrients may be only present in some particular foods, and in case these foods are not consumed by the households, consumption of these nutrients will be zero. Households may be facing non-negativity constraints which at current income and prices make it optimal to consume only some foods, i.e. zero expenditures reflect corner solutions.

Estimation of the income elasticity of nutrient consumption on a sample that does not include zero consumption (as in our case since we use variables in logs) might lead to biased estimates, especially for the sample of households at the bottom part of the distribution of PCE. While the bias might depend upon different factors other than zero consumption (such as endogeneity of PCE), simple intuition suggests the presence of a downward bias of the estimated elasticity: provided that households with zero intakes are those at a corner solution (i.e., poorer households) the selected sample of those with positive intake will consist of better-off families for which we expect the nutrient-income elasticity to be lower.

[14] This finding in part confirms that for the sample "above the median of PCE" the assumption of linearity of the relationship nutrient intake – income is more difficult to maintain.

Figure 2

In figure 2 we plot the percentage of zero nutrient intakes against the 20 quantiles of PCE. The general pattern that emerges is that zero intakes tend to be present most frequently below the 5th quantile of PCE. In addition, only two nutrients show a relevant fraction of zero values: cholesterol and heme iron[15] (and possibly vitamin A and monosaturated fat). Accordingly, we focus on these two nutrients and report in table 3 the percentages of households with zero values for each quantile of PCE.

Table 3

In order to investigate the determinants of zero consumption of cholesterol and heme iron, table 4 presents the estimates of a probit model where the dependent variable is a binary variable taking the value of 1 if the household reports zero consumption of the particular micronutrient and 0 otherwise, and the independent variables are the same socioeconomic variables used in the regression model of equation (1). As before, two specifications are estimated, one without and one with locality fixed effects. The *ln*PCE is instrumented by the same set of variables used in the FE-IV specification (see above). As table 4 reveals, an increase in PCE lowers the probability of zero consumption for both cholesterol and heme iron (with the effect being remarkably high for heme iron, -18.9% if controlling for locality effect). For cholesterol, the main determinant of zero consumption appears to be PCE. The coefficients of the rest of the regressors are either not significant, or, if significant, very low. However, for heme iron it appears that, in addition to PCE, a number of other variables have a significant effect on the probability of a zero intake. In particular, household composition matters: overall,

[15] This finding is consistent with the 1999 National Nutrition Survey of Mexico identifies zinc and iron deficiency as a major nutritional problem in Mexican children (Barquera et al., 2003a).

a larger household size is found to decrease the probability of zero intakes; households with more members in the age group 10-14 tend to have a higher probability of zero consumption with this effect being slightly stronger when households have more females between 10 and 14 years of age. Another interesting finding is that probability of zero consumption for heme iron seems to increase when household partner speaks indigenous language (in the specification without locality effect).

Table 4

Given the prevalence of zero values for level of PCE in the consumption of cholesterol and heme iron, we also re-estimated the income elasticity of these two micronutrients with three estimators that take into account the presence of zero values: censored least absolute deviation estimator (CLAD), TOBIT and TOBIT-IV. The CLAD relies on much weaker distributional assumptions than the TOBIT method, but it cannot easily control for endogenous regressors.[16] Table 5 reports the results of these estimators together with the income elasticity estimates obtained using OLS and IV on the sample that does not include the zero values, for comparison purposes. It is important to keep in mind that the objective of table 5 is to shed some light on the sensitivity of the income elasticity estimates to the zero censoring in the dependent variable. Given that the CLAD and TOBIT methods are practically impossible to implement with 240 dummies for each village in our sample, we have opted to control for state-level fixed effects rather than village level-fixed effects.[17]

Table 5

[16] For a more intuitive explanation of the CLAD see Deaton (1997). Blundell and Powell (2004) provide a description of more recent developments.

[17] This explains why the OLS and the IV income elasticity estimates for cholesterol and heme iron in table 5 are not identical to the FE-OLS and FE-IV estimates in table 2.

Our findings suggest that the presence of zero intakes is a very mild source of bias in the estimation of the elasticity cholesterol-income. The income elasticity of cholesterol based o OLS (that does not take into account measurement error in *ln*PCE) is 0.766 while the comparable estimate using CLAD is 0.802 (or 0.665 using TOBIT). Using instrumental variables to control for measurement error in *ln*PCE, leads to a lower (than OLS) elasticity estimate of 0.532, and a lower estimate of 0.427 when the TOBIT-IV method is used. More striking differences are observed for heme iron, the micronutrient that had the highest frequency of zero values in our sample (about 23 percent of the households in our sample report zero consumption of heme iron). The income elasticity of heme iron almost doubles when censoring at zero is taken into account. For example, the TOBIT methods yields an income elasticity of 1.418 compared to an elasticity of 0.786 with OLS, and a similar pattern is observed when one employs instrumental variable methods (the income elasticity of 0.480 with IV increases to 0.816 when the TOBIT IV method is employed).

5. Concluding remarks

This paper provides estimates of the extent to which micronutrient consumption at the household level responds to increases in household income. The income elasticity for a specific micronutrient, the parameter that summarizes the percentage change in the consumption of a specific micronutrient corresponding to a one percent change in household income, is critical to understanding one of the key determinants of consumption of micronutrients. As household income increases, households may change the composition of their food consumption, and thus their intakes of specific micronutrients. If increases in income result in changes in the diet of households towards foods with higher micronutrient content (for example, eating more vegetables/fruits and meat), then micronutrient deficiencies may fall.

The nutrient-income elasticity is estimated using a linear regression model controlling both for the clustered nature of our data and for the bias due to measurement error in nutrient consumption at the household level. Our preferred estimates (instrumental variable-fixed effect specification for the sample of all households) show a sizeable positive elasticity for some micronutrients (especially vitamin A 0.8, vitamin C 0.69 and calcium 0.45). For other micronutrients the effect of income on the intake is still significant but very small (elasticity for fiber is only 0.09 and for iron 0.08).

We also test for the robustness of our estimates using a semi-parametric estimator (partially linear model) and whether the presence of zero intakes for specific micronutrients in our sample, such as cholesterol and heme iron, can be a source of bias for the estimated income elasticities. The semi-parametric plots suggest that, for most, if not all, nutrients a linear form is a good description of the relationship between nutrient and PCE around the median of *lnPCE.* Not surprisingly, our sensitivity analysis confirms that the bias of the estimated income elasticity for some key micronutrients depends on the extent to which households in any given sample consume a positive amount of that micronutrient. The income elasticity of heme iron, the micronutrient with the highest frequency of zero values in our sample (about 23 percent of the households in our sample), almost doubles when we employ a statistical method to control for censoring at zero.

Overall our estimates establish that increases in income are associated with significant and sizeable increases not only in the consumption of calories but also in the consumption of vital micronutrients among poor households in rural Mexico. Thus, increases in household income resulting from participation in poverty alleviation programs that provide direct (and unconditional) cash transfers, or economic policies that result in higher rural wages, and increased profitability of agricultural production are accompanied by increases in the consumption of key micronutrients at the household level.

One critical question is whether increases in micronutrient consumption at the household level translate to increases in the intake of key micronutrients by infants and other vulnerable children to micronutrient deficiencies. Perhaps alternative approaches that are more direct may be more effective. For example, in-kind transfers of key food items that provide the essential micronutrients may be more effective than direct cash transfers to their parents at decreasing malnutrition among infants and young children. It is hoped that future research as well as the data collected over the next rounds for the evaluation of the PAL program will be able to shed more light on this issue.

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Table 1 – Per capita daily nutrient consumption

Nutrient	All			bottom 25% of PCE			top 25% of PCE		
	mean	median	IQ range	mean	median	IQ range	mean	median	IQ range
Energy (kcal)	2203	2086	1162	1657	1549	853	2700	2653	1231
Fiber (g)	35.7	32.9	21.9	31.7	28.3	20.6	39.3	37.3	22
Protein (g)	56.1	52.5	31.3	40.63	37.2	23.1	72.6	70.7	32.8
Fat (g)	59.4	54.3	38.4	33	21.9	10.4	84.7	81	44.2
Cholesterol (mg)	147.2	117.3	121.4	63.1	50.5	69.9	231.5	185.5	151.8
Saturated fat (g)	15.6	13.6	11.8	7.2	6.6	5	23.9	22.4	12.9
Monounsaturated fat (g)	20	18.1	13.5	10.6	9.9	7	29	27.7	15.8
Polyunsaturated fat (g)	14	12.3	12	7.4	6.5	6.7	20	18.3	14
Carbohydrates (g)	364.4	338.9	204	303.4	278.4	180.7	413.9	395.2	206.5
Vitamin A (mcg ER)	158.6	122	155.2	53	41.2	51	283.5	250.8	200.7
Vitamin C (mcg)	73.6	50.2	69.3	28.5	18.9	26.61	128.7	96.6	95.3
Folate (mcg)	417.6	373.8	258.4	334.4	278.2	218	507.7	474.4	275.9
Iron (mg)	15.6	14.1	10	14.1	12.7	9.46	16.9	15.6	9.4
Heme iron (mg)	0.155	0.109	0.187	0.044	0	0.068	0.288	0.236	0.272
Zinc (mg)	8.71	5.81	2.84	7.1	6.42	4.64	10.3	9.8	5.1
Calcium (mg)	609.9	495.5	628.1	258	182.7	185.7	1004.4	942.2	677.4

Table 2 – Elasticity nutrient-per capita expenditure

	All households		Below the median		Above the median	
Obs	6040	5974	2993	2935	3048	3040
Nutrient	***FE-OLS***	***FE-IV***	***FE-OLS***	***FE-IV***	***FE-OLS***	***FE-IV***
Energy	0.46 *(0.012)****	0.20 *(0.018)****	0.51 *(0.022)****	0.02 *(0.052)*	0.43 *(0.023)****	-0.28 *(0.050)****
Fiber	0.32 *(0.022)****	0.09 *(0.029)****	0.40 *(0.035)****	-0.07 *(0.076)****	0.22 *(0.042)****	-0.34 *(0.093)****
Protein	0.51 *(0.019)****	0.22 *(0.025)****	0.56 *(0.030)****	0.011 *(0.063)*	0.44 *(0.039)****	-0.34 *(0.082)****
Fat	0.51 *(0.019)****	0.28 *(0.027)****	0.62 *(0.036)****	0.12 *(0.060)***	0.40 *(0.046)****	-0.20 *(0.095)***
Cholesterol	0.91 *(0.029)****	0.61 *(0.043)****	1.14 *(0.068)****	0.58 *(0.129)****	0.73 *(0.051)****	-0.16 *(0.102)**
Saturated fat	0.65 *(0.021)****	0.37 *(0.030)****	0.77 *(0.041)****	0.18 *(0.068)****	0.54 *(0.050)****	-0.20 *(0.098)****
Monounsaturated fat	0.56 *(0.018)****	0.31 *(0.026)****	0.68 *(0.032)****	0.16 *(0.061)****	0.44 *(0.035)****	-0.15 *(0.071)****
Polyunsaturated fat	0.51 *(0.032)****	0.33 *(0.045)****	0.70 *(0.073)****	0.25 *(0.122)****	0.29 *(0.054)****	-0.04 *(0.108)*
Carbohydrates	0.36 *(0.016)****	0.11 *(0.023)****	0.45 *(0.030)****	-0.05 *(0.061)*	0.27 *(0.033)****	-0.35 *(0.070)****
Vitamin A	1.22 *(0.032)****	0.80 *(0.047)****	1.53 *(0.074)****	0.58 *(0.135)****	1.01 *(0.053)****	0.02 *(0.071)*
Vitamin C	1.06 *(0.035)****	0.69 *(0.049)****	1.24 *(0.069)****	0.49 *(0.124)****	0.85 *(0.062)****	-0.11 *(0.153)*
Folate	0.40 *(0.021)****	0.18 *(0.029)****	0.46 *(0.036)****	0.02 *(0.076)*	0.33 *(0.036)****	-0.21 *(0.084)****
Iron	0.34 *(0.020)****	0.08 *(0.027)****	0.41 *(0.032)****	-0.09 *(0.069)**	0.28 *(0.039)****	-0.38 *(0.078)****
Heme iron	0.83 *(0.026)****	0.43 *(0.043)****	0.82 *(0.055)****	0.17 *(0.140)*	0.081 *(0.056)****	-0.35 *(0.141)****
Zinc	0.44 *(0.020)****	0.17 *(0.027)****	0.50 *(0.033)****	-0.03 *(0.070)*	0.39 *(0.040)****	-0.34 *(0.080)****
Calcium	0.77 *(0.021)****	0.45 *(0.035)****	0.86 *(0.038)****	0.23 *(0.082)****	0.67 *(0.048)****	-0.19 *(0.100)***

Standard error in brackets; (significant at 10%, ** significant at 5%,, *** significant at 1%*

Table 3: Percentage of zeros for heme iron and cholesterol

Quantile of PCE	Heme iron		Cholesterol	
	%	*Standard Deviation*	%	*Standard Deviation*
1	78	*41.4*	42.1	*49.4*
2	58.5	*49.3*	17.3	*37.9*
3	43.7	*49.6*	9.8	*29.8*
4	32.7	*46.9*	4	*19.7*
5	31.7	*46.6*	4.6	*21*
6	26.3	*44.1*	3.4	*18.3*
7	26.6	*44.2*	2	*14.1*
8	21.1	*40.9*	2.6	*15.9*
9	20.2	*40.2*	1.1	*10.7*
10	15	*35.8*	1.4	*11.9*
11	11.3	*31.7*	1.1	*10.7*
12	17.1	*37.7*	3.7	*19*
13	14.7	*35.5*	1.4	*11.9*
14	9.8	*29.4*	1.4	*10.7*
15	8.4	*27.7*	0.5	*7.6*
16	12.1	*32.7*	1.4	*11.9*
17	7.2	*25.9*	0.2	*5.3*
18	6	*23.9*	1.1	*10.7*
19	6.9	*24.5*	2.3	*13.1*
20	7.2	*25.9*	1.1	*10.7*
Overall	24.8	*43.2*	7.6	*26.6*

Table 4 - Determinants of the probability of zero intake

Marginal effect reported

PROBIT-IV	Cholesterol		Heme iron	
	no locality effect	with locality effect	no locality effect	with locality effect
lpce	-0.030	-0.028	-0.184	-0.169
	(0.004)***	(0.004)***	(0.015)***	(0.018)***
agehead	-0.000	-0.000	0.000	-0.002
	(0.000)	(0.000)	(0.002)	(0.002)
agehead2	-0.000	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
agewife	-0.000	-0.000	0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.001)
agewife2	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
schoolhead==1	-0.006	-0.005	-0.005	-0.005
	(0.004)	(0.004)	(0.029)	(0.029)
schoolhead==2	-0.005	-0.004	0.005	0.001
	(0.004)	(0.003)	(0.018)	(0.019)
schoolhead==3	-0.004	-0.004	-0.016	-0.014
	(0.004)	(0.003)	(0.020)	(0.020)
schoolhead==4	0.006	0.007	-0.003	-0.006
	(0.008)	(0.008)	(0.028)	(0.028)
schoolhead==5	-0.002	-0.001	-0.022	0.002
	(0.005)	(0.005)	(0.021)	(0.023)
schoolhead==6	0.005	0.005	-0.045	-0.020
	(0.007)	(0.007)	(0.022)**	(0.025)
alfawife	-0.002	-0.002	-0.006	-0.012
	(0.003)	(0.002)	(0.011)	(0.011)
indigenahead	-0.001	-0.000	-0.005	-0.024
	(0.005)	(0.005)	(0.025)	(0.030)
indigenawife	0.016	0.014	0.048	0.013
	(0.009)*	(0.008)*	(0.029)*	(0.030)
medright	0.000	0.000	-0.005	-0.002
	(0.001)	(0.001)	(0.006)	(0.007)
missingmedright	0.002	0.003	0.038	0.035
	(0.006)	(0.006)	(0.024)	(0.025)
missingspanishmean	-0.012	-0.012	-0.141	-0.109
	(0.015)	(0.014)	(0.073)*	(0.079)
missingmathmean	-0.009	-0.009	0.185	0.212
	(0.017)	(0.015)	(0.131)	(0.143)
mathmean	-0.001	-0.001	0.017	0.018
	(0.002)	(0.002)	(0.010)*	(0.010)*
spanishmean	-0.002	-0.002	-0.021	-0.016
	(0.002)	(0.002)	(0.010)**	(0.010)
schoolgowife	0.005	0.009	0.011	0.070
	(0.013)	(0.015)	(0.048)	(0.062)

radio==1	-0.004	-0.004	-0.049	-0.059
	(0.005)	(0.005)	(0.024)**	(0.022)***
radio==2	-0.007	-0.006	-0.048	-0.051
	(0.003)**	(0.003)**	(0.012)***	(0.013)***
tele==1	-0.005	-0.004	-0.048	-0.038
	(0.005)	(0.005)	(0.024)**	(0.026)
tele==2	-0.015	-0.014	-0.091	-0.073
	(0.004)***	(0.004)***	(0.014)***	(0.015)***
male04	-0.004	-0.004	-0.018	-0.024
	(0.002)*	(0.002)*	(0.010)*	(0.010)**
male59	-0.004	-0.004	-0.020	-0.026
	(0.002)**	(0.002)**	(0.009)**	(0.010)***
male1014	0.000	0.000	-0.006	0.001
	(0.002)	(0.002)	(0.009)	(0.009)
male1554	-0.001	-0.001	-0.017	-0.014
	(0.002)	(0.002)	(0.007)**	(0.007)*
male55plus	0.008	0.008	-0.001	-0.002
	(0.004)**	(0.004)**	(0.018)	(0.018)
female04	-0.002	-0.002	-0.017	-0.019
	(0.002)	(0.002)	(0.010)*	(0.011)*
female59	-0.003	-0.003	-0.027	-0.025
	(0.002)	(0.002)	(0.010)***	(0.010)**
female1014	0.000	-0.000	0.004	0.007
	(0.002)	(0.002)	(0.009)	(0.010)
female1554	-0.001	-0.001	-0.013	-0.011
	(0.002)	(0.002)	(0.007)*	(0.007)
Observations	6234	6080	6234	6080

Standard errors in brackets; * significant at 10%; ** significant at 5%; *** significant at 1%;
A description of the variables included is in appendix A.

Table 5 - Income Elasticity Cholesterol and Heme Iron

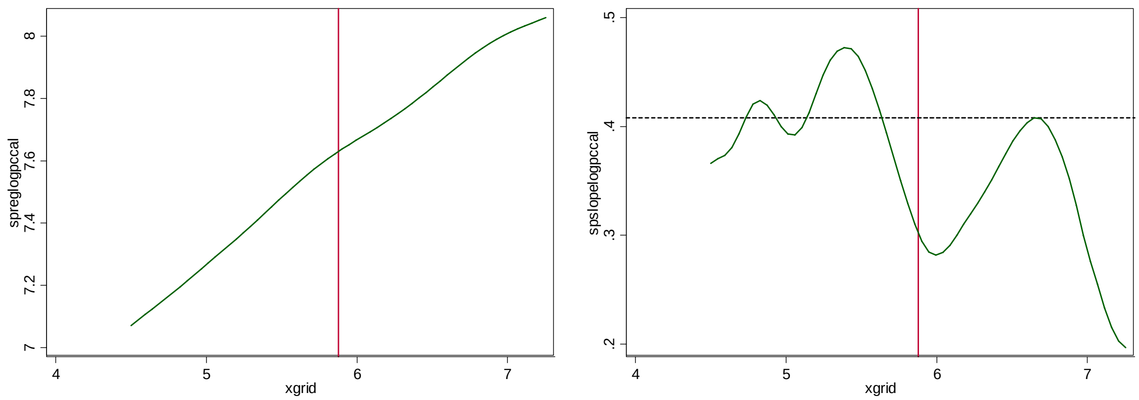
	OLS	IV	CLAD	TOBIT	TOBIT-IV
Cholesterol	0.766	0.532	0.802	0.665	0.427
	*(0.023)****	*(0.030)****	*(0.030)****	*(0.029)****	*(0.040)****
Observations	6039	5981	6319	6319	6307
Percentage of zeros+	4.4%, *standard deviation 20.5%*				
Heme Iron	0.786	0.480	1.519	1.418	0.816
	*(0.022)****	*(0.035)****	*(0.073)****	*(0.046)****	*(0.183)****
Observations	4980	4859	6319	6319	6307
Percentage of zeros+	22.6%, s*tandard deviation 41.8*				

State fixed effects included in all the specifications; Standard errors in brackets, ***=significant at 1%
+=percentage is calculated on the estimation sample used for CLAD and TOBIT, 6319 observations.
Tobit-IV -Wald test of exogeneity:
Colesterol: chi2(1) = 78.13 Prob > chi2 = 0.0000
Iron Heme: chi2(1) = 136.07 Prob > chi2 = 0.0000

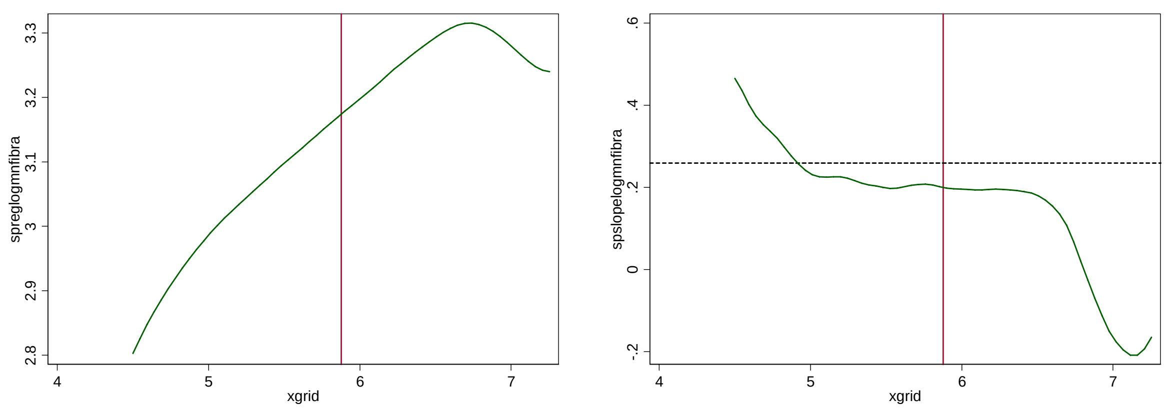
Figure 1 – Semiparametric estimation of the relationship between log daily per capita nutrient and log per capita expenditure

(left panel: function, right panel: elasticity, the vertical line in both panels is at the median of lpce, the horizontal line in the right panel is the mean slope below the median ***)***

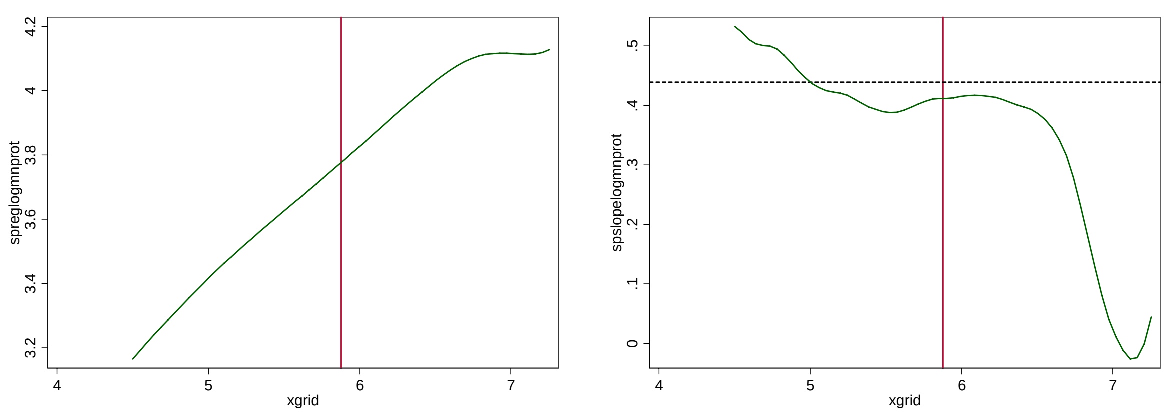
1.1 – Energy (kcal)



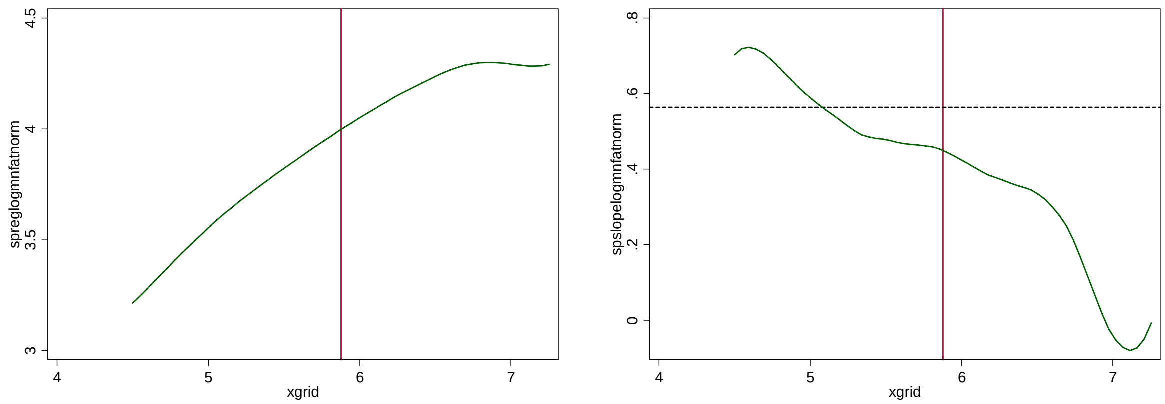
1.2 – Fiber



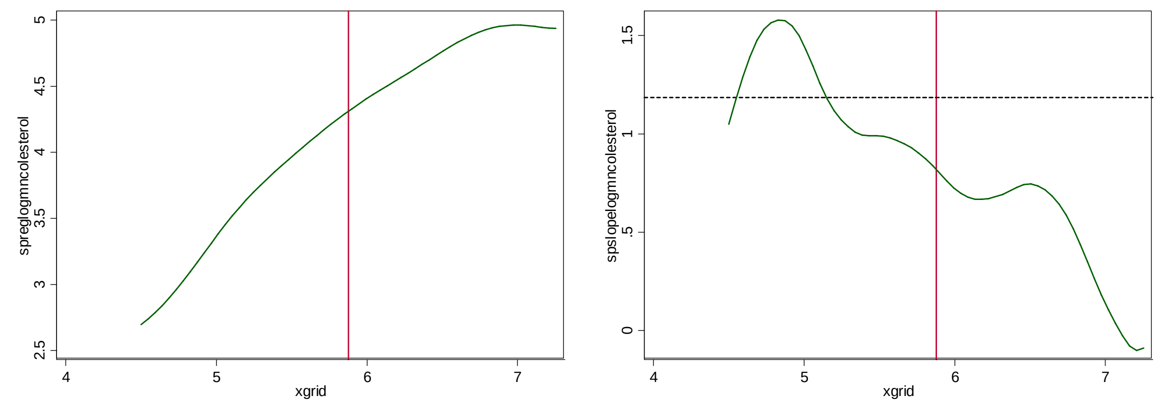
1.3 – Protein



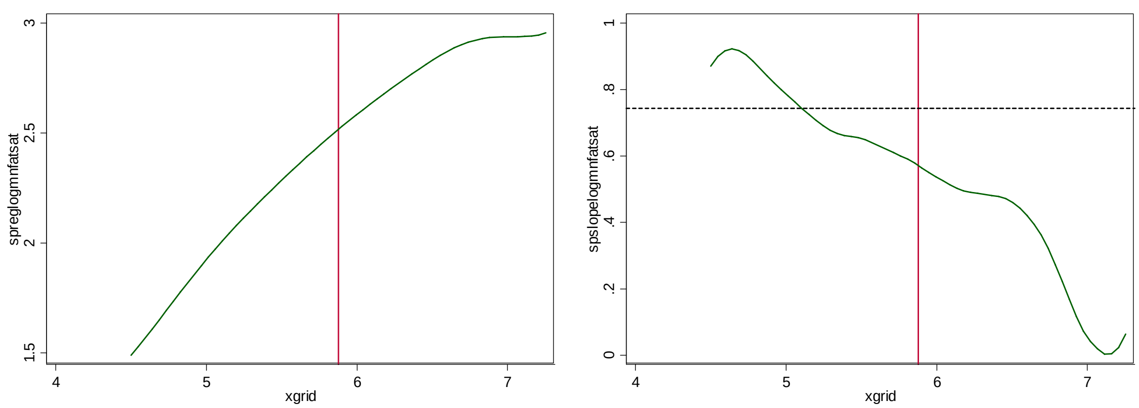
1.4 – Fat



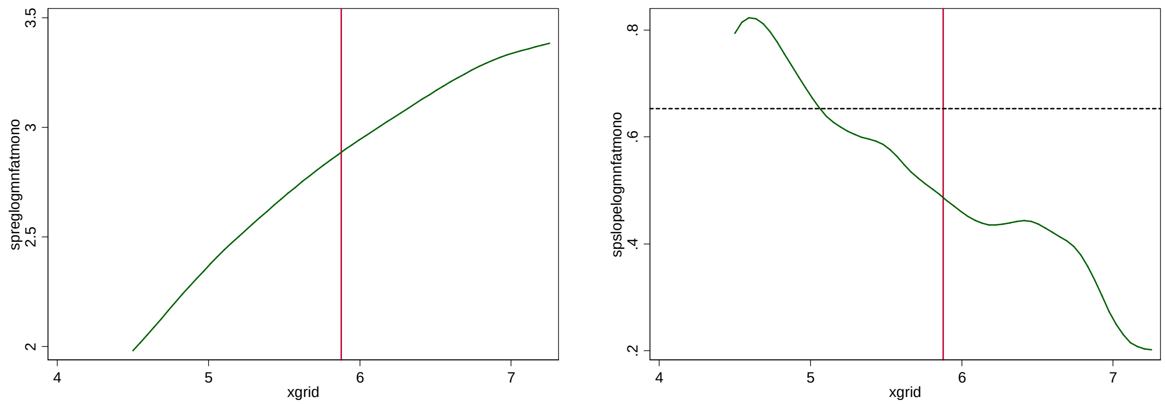
1.5 - Cholesterol



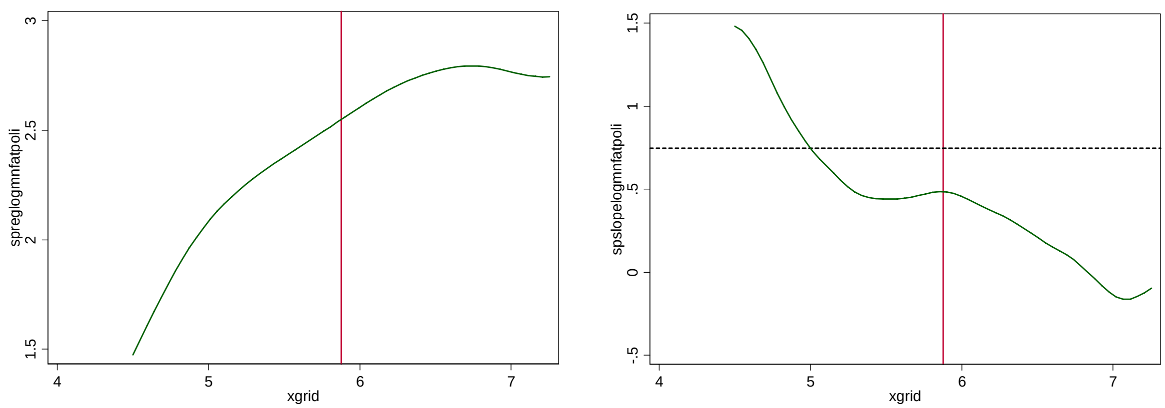
1.6 – Saturated fat



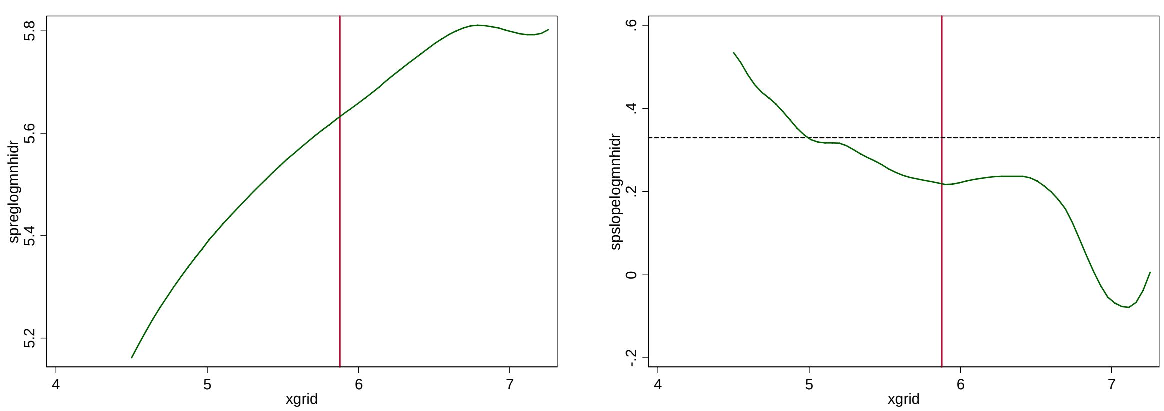
1.7 – Monounsaturated Fat



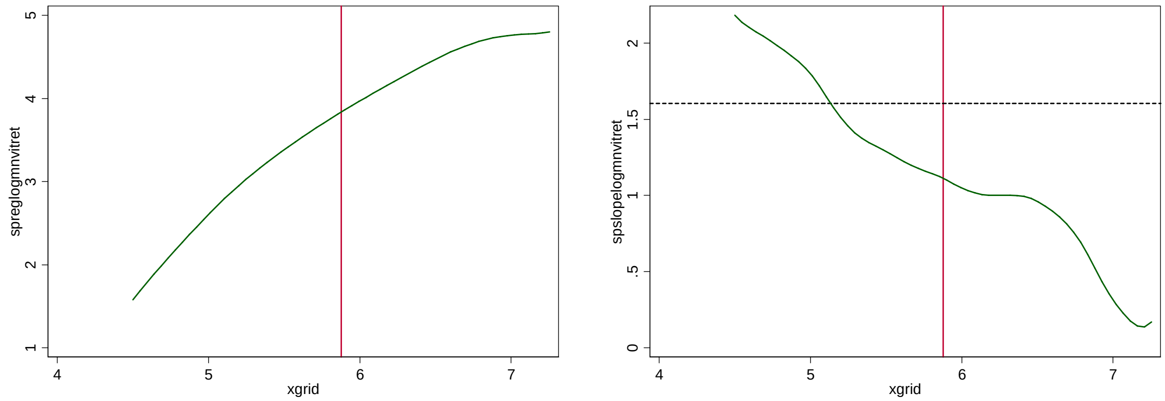
1.8 – Polyunsaturated Fat



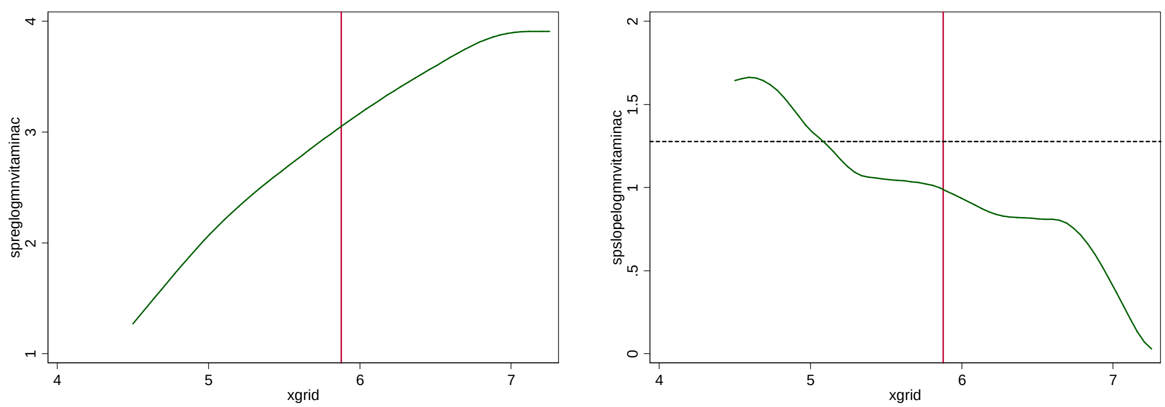
1.9 – Carbohydrates



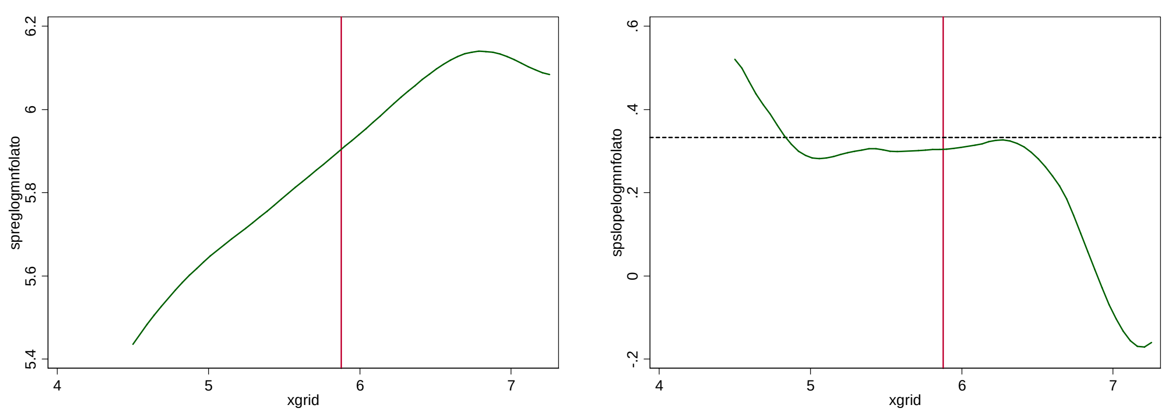
1.10 – Vitamin A



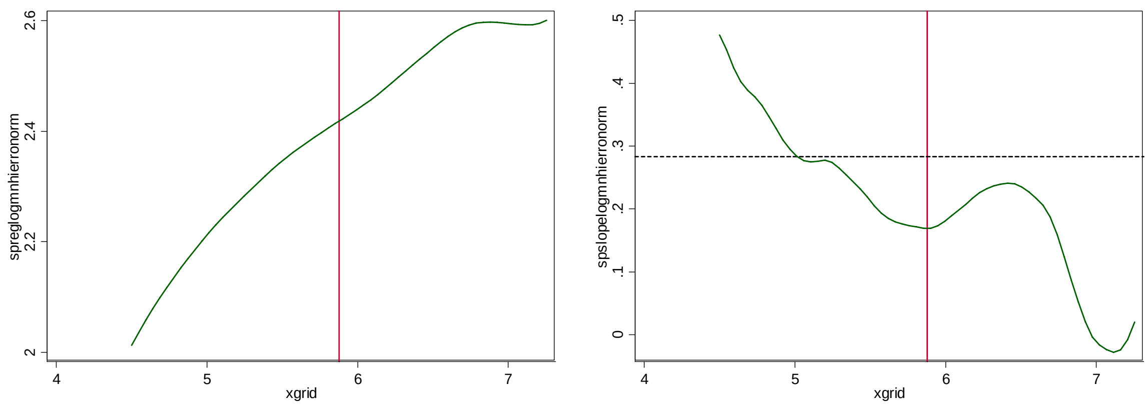
1.11 – Vitamin C



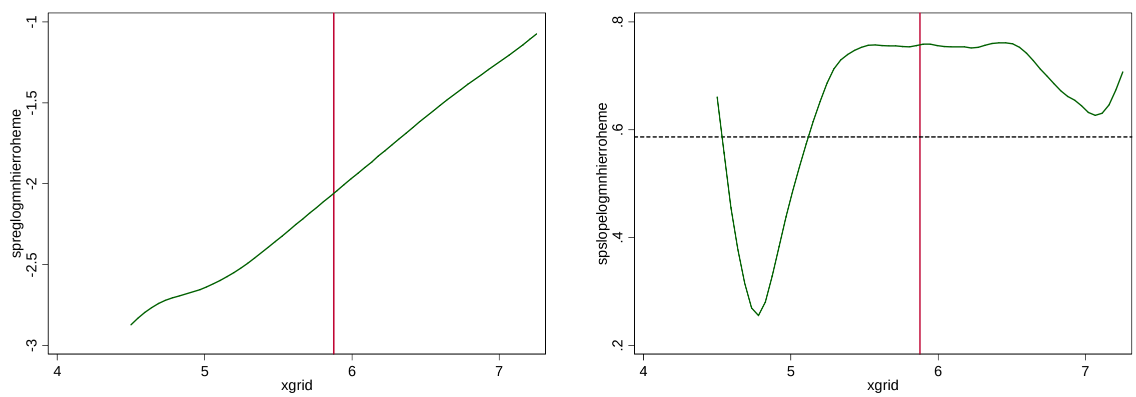
1.12 - Folate



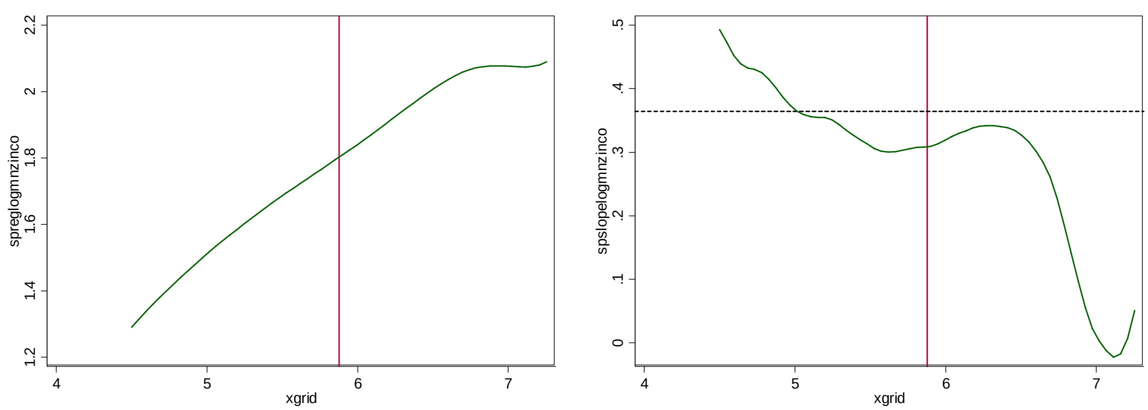
1.13 – Iron



1.14 – Heme iron



1.15 – Zinc



1.16 – Calcium

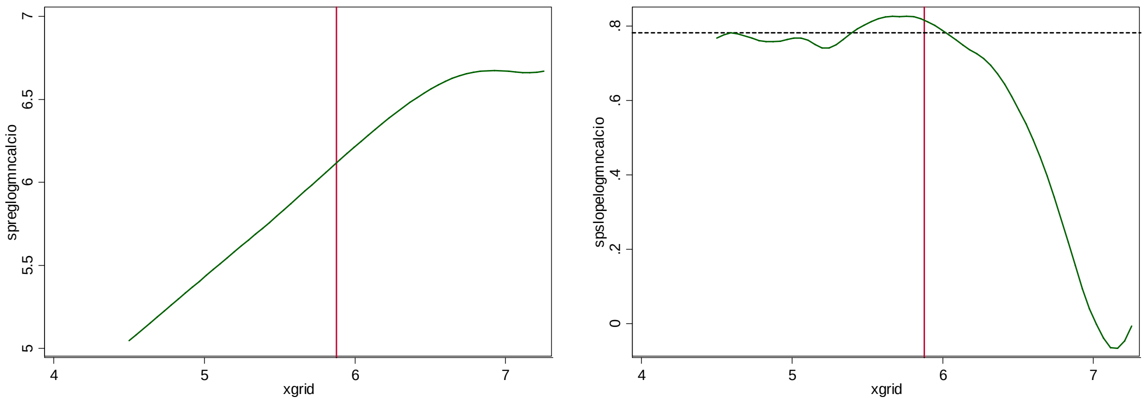
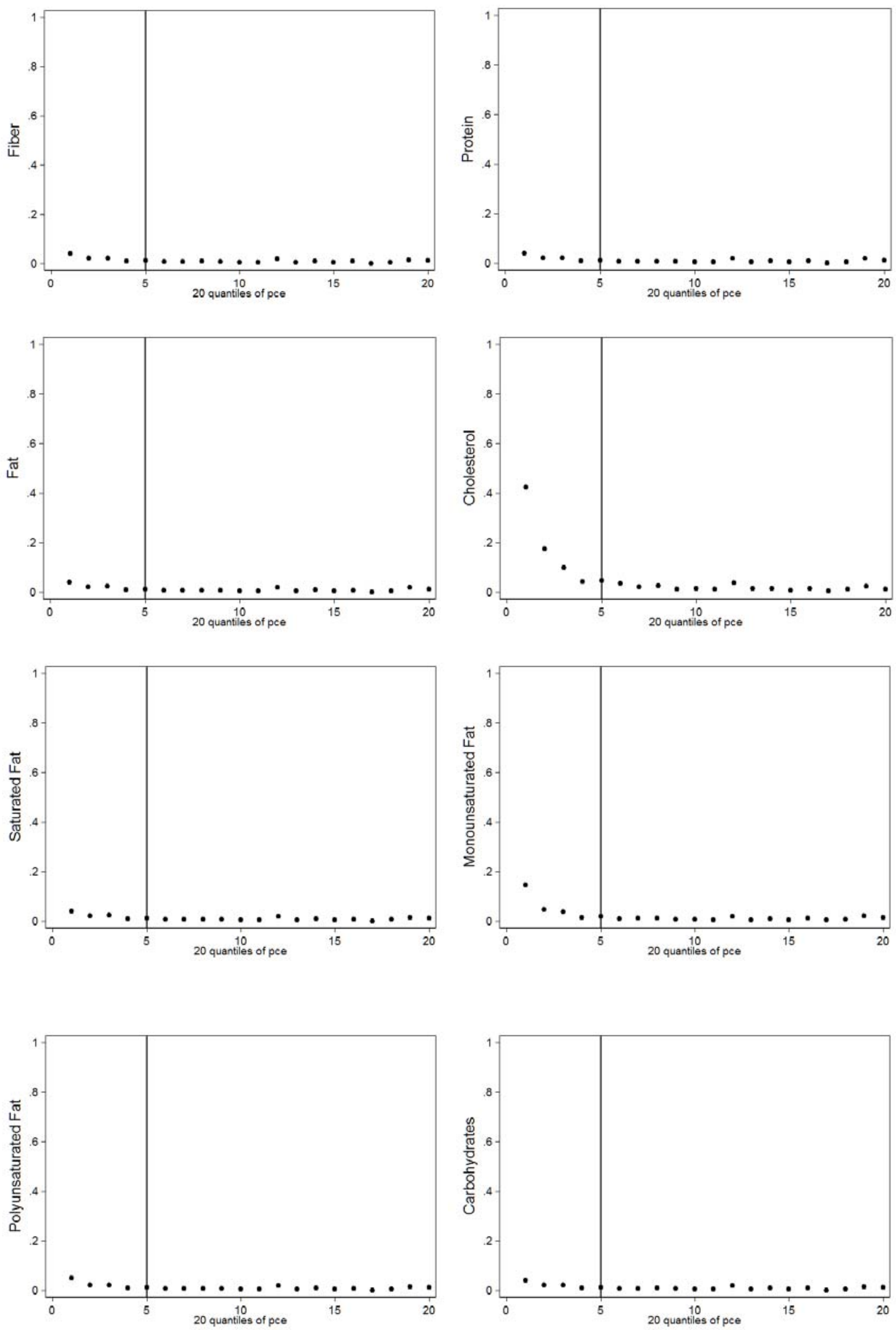
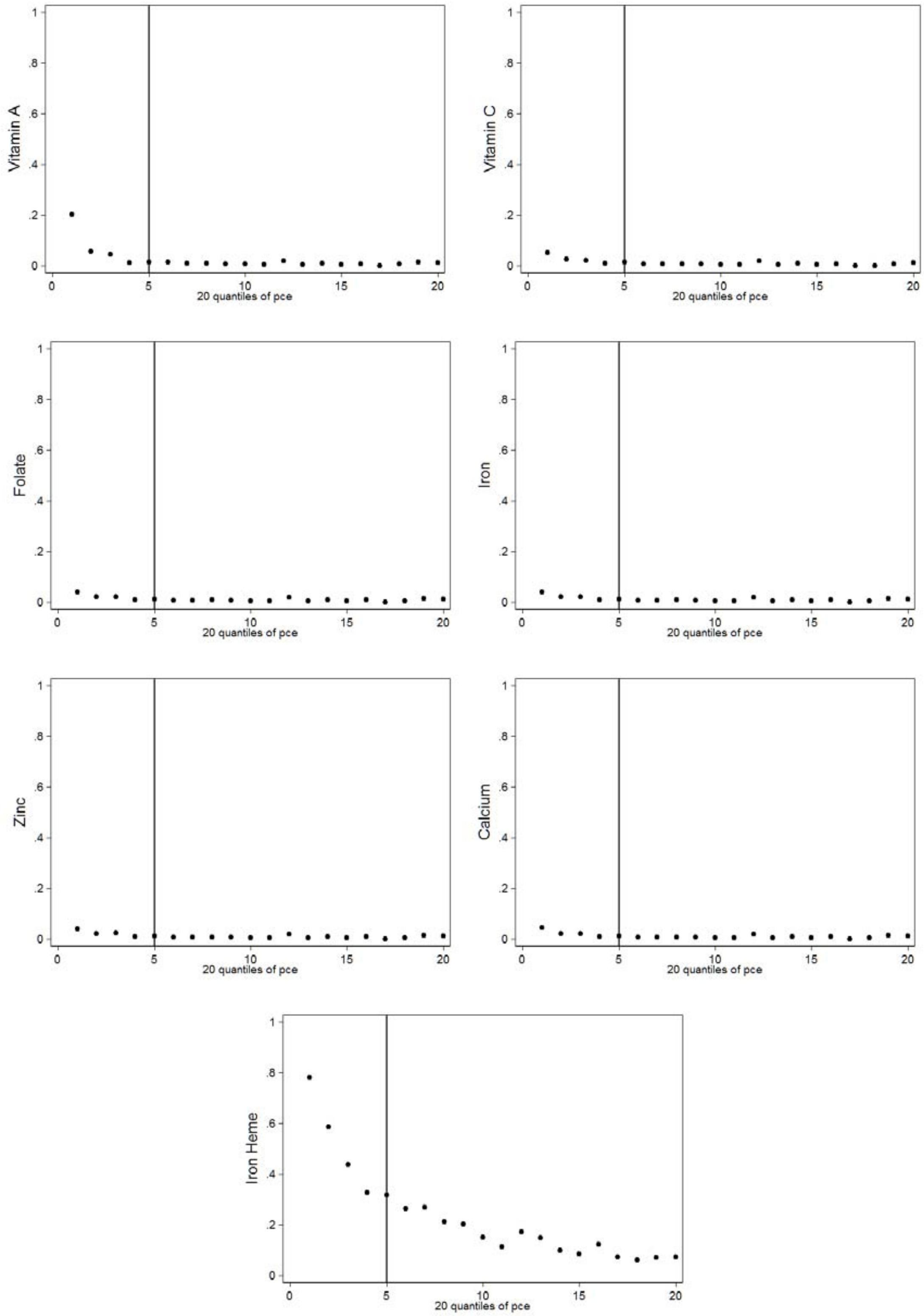


Figure 2 - Percentage of zero nutrient intakes against the 20 quantiles of PCE




Vitamin A
20 quantiles of pce
Vitamin C
20 quantiles of pce
Folate
20 quantiles of pce
Iron
20 quantiles of pce
Zinc
20 quantiles of pce
Calcium
20 quantiles of pce
Iron Heme
20 quantiles of pce

Appendix A – Description of variables

Variable	Mean	Standard Deviation	Description
size	4.68	2.12	Household (HH) size
agehead	44.39	15.55	Age of HH head
agewife	31.90	19.30	Age of HH partner
_Ischoolhead_0	0.10	0.30	Dummies for the school level of the HH head: 0=no education, 1=kindergarten, 2=incomplete primary, 3=complete primary, 4=incomplete secondary, 5=complete secondary, 6=other
_Ischoolhead_1	0.05	0.21	
_Ischoolhead_2	0.41	0.49	
_Ischoolhead_3	0.19	0.39	
_Ischoolhead_4	0.05	0.22	
_Ischoolhead_5	0.13	0.34	
_Ischoolhead_6	0.08	0.27	
alfawife	0.58	0.49	Dummy for HH partner is literate
indigenahead	0.17	0.37	Dummy for HH head speaking indigenous language
indigenawife	0.15	0.35	Dummy for HH partner speaking indigenous language
medright	0.63	1.56	Number of HH members that have access to medical rights.
schoolgowife	0.011	0.10	Dummy for HH partner going to school
spanishmean	5.93	3.37	Test score in Spanish in the last school grade attended
mathmean	5.88	3.37	Test score in Math in the last school grade attended
workhead	0.77	0.42	Dummy for HH head working
workwife	0.048	0.21	Dummy for HH partner working
_Iradio_0	0.35	0.48	Ownership of radio: 0=does not have, 1=it has but not working, 2=it has and it works
_Iradio_1	0.04	0.19	
_Iradio_2	0.61	0.49	
_Itele_0	0.32	0.47	Ownership of television: 0=does not have, 1=it has but not working, 2=it has and it works
_Itele_1	0.03	0.18	
_Itele_2	0.65	0.48	
male04	0.31	0.57	Number of males age 0 - 4
male59	0.32	0.58	…………………………5 - 9
male1014	0.32	0.59	…………………………10 -14
male1554	1.12	0.85	…………………………15 - 54
male55plus	0.23	0.43	…………………………..55 and older
female04	0.29	0.55	Number of females age 0 – 4
female59	0.32	0.57	…………………………5 – 9
female1014	0.30	0.57	…………………………10 -14
female1554	1.23	0.81	…………………………15 – 54
female55plus	0.23	0.44	…………………………..55 and older
non food	182.77	221.13	HH expenditure for non food items

piso	0.31	0.46	Dummy =1 if dirt floor
wall	0.043	0.20	Dummy =1 if wall material is cardboard, palm, reed or bamboo
roof	0.15	0.35	Dummy =1 if roof material is cardboard, palm, wood tiles
_Ikitchensleep_0	0.17	0.37	Presence of kitchen: 0=does not have, 1=it has and it is not used as bedroom, 2=it has and it is used as bedroom
_Ikitchensleep_1	0.75	0.43	
_Ikitchensleep_2	0.08	0.27	
serviciosan	0.15	0.35	Dummy =1 if there is no toilet or type of toilet is pit.
luz	0.12	0.32	Dummy =1 if there is no electricity
refrigerador	0.45	0.50	Dummy =1 if the household owns a fridge
estufa	0.58	0.49	Dummy =1 if the household owns a gas heater

APPENDIX B First stage regressions of 2SLS

B.1 Energy (kcal), Fiber, Protein, Fat, Saturated Fat, Monounsaturated and Polyunsaturated Fat, Carbohydrates, Folate, Zinc, Vitamin C

```
First-stage regressions
-----------------------

      Source |       SS       df       MS              Number of obs =    5955
-------------+------------------------------           F(260,  5694) =   41.47
       Model |  1197.77187   260  4.60681489           Prob > F      =  0.0000
    Residual |  632.575683  5694  .111095132           R-squared     =  0.6544
-------------+------------------------------           Adj R-squared =  0.6386
       Total |  1830.34756  5954  .307414772           Root MSE      =  .33331

------------------------------------------------------------------------------
        lPCE |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     agehead |    .005412   .0017811     3.04   0.002     .0019204    .0089037
    agehead2 |  -.0000634   .0000187    -3.40   0.001       -.0001   -.0000268
     agewife |  -.0010261   .0008627    -1.19   0.234    -.0027174    .0006652
    agewife2 |   2.63e-06   .0000144     0.18   0.855    -.0000256    .0000308
_Ischoolhe~1 |    .012355   .0252481     0.49   0.625    -.0371408    .0618509
_Ischoolhe~2 |   .0011345   .0162179     0.07   0.944    -.0306587    .0329277
_Ischoolhe~3 |   .0074551   .0180358     0.41   0.679     -.027902    .0428122
_Ischoolhe~4 |   .0064294   .0245838     0.26   0.794    -.0417642    .0546231
_Ischoolhe~5 |  -.0090001   .0196672    -0.46   0.647    -.0475552    .0295551
_Ischoolhe~6 |   .0245767   .0221722     1.11   0.268    -.0188893    .0680427
    alfawife |   .0019274   .0097078     0.20   0.843    -.0171036    .0209585
 indigenahead |  -.0057937   .0286243    -0.20   0.840    -.0619083    .0503209
 indigenawife |   .0083446   .0258263     0.32   0.747    -.0422848     .058974
    medright |    .015149   .0055681     2.72   0.007     .0042335    .0260646
missingmed~t |  -.0612241    .021803    -2.81   0.005    -.1039663    -.018482
missi~shmean |   .0708073   .0948687     0.75   0.455    -.1151715     .256786
missingm~ean |   .0725881   .0922965     0.79   0.432    -.1083482    .2535244
    mathmean |   .0124454   .0083009     1.50   0.134    -.0038275    .0287183
 spanishmean |   .0076431   .0086837     0.88   0.379    -.0093802    .0246664
schoolgowife |   .0321976   .0420379     0.77   0.444    -.0502127    .1146079
      male04 |  -.0915896   .0085407   -10.72   0.000    -.1083326   -.0748465
      male59 |  -.0749864   .0081699    -9.18   0.000    -.0910026   -.0589702
    male1014 |  -.0312717   .0079695    -3.92   0.000     -.046895   -.0156485
    male1554 |   -.038273   .0060696    -6.31   0.000    -.0501716   -.0263743
  male55plus |  -.0414136   .0154831    -2.67   0.007    -.0717664   -.0110609
    female04 |  -.0880964    .008867    -9.94   0.000    -.1054791   -.0707138
    female59 |  -.0570919   .0082382    -6.93   0.000    -.0732419   -.0409419
  female1014 |  -.0607804   .0081563    -7.45   0.000    -.0767698    -.044791
  female1554 |  -.0291271   .0060999    -4.78   0.000    -.0410852    -.017169
  lognonfood |   .2945513   .0050683    58.12   0.000     .2846154    .3044872
        piso |   .0121302   .0130174     0.93   0.351    -.0133888    .0376492
        wall |  -.0332522   .0239689    -1.39   0.165    -.0802403    .0137359
        roof |    .006157   .0155165     0.40   0.692    -.0242612    .0365752
_Ikitchens~1 |   -.013101   .0128586    -1.02   0.308    -.0383087    .0121067
_Ikitchens~2 |   -.023212    .020336    -1.14   0.254    -.0630782    .0166543
 serviciosan |   .0093151   .0166236     0.56   0.575    -.0232735    .0419037
         luz |   .0035124   .0220854     0.16   0.874    -.0397834    .0468081
refrigerador |   .0045326   .0115313     0.39   0.694    -.0180731    .0271384
      estufa |   .0177582   .0128196     1.39   0.166    -.0073731    .0428895
       _cons |   4.819139   .3450453    13.97   0.000     4.142719     5.49556
------------------------------------------------------------------------------
```

B.2 Cholesterol

First-stage regressions

Source	SS	df	MS
Model	1091.92271	256	4.26532309
Residual	592.061631	5548	.106716228
Total	1683.98434	5804	.29014203

Number of obs	= 5805
F(256, 5548)	= 39.97
Prob > F	= 0.0000
R-squared	= 0.6484
Adj R-squared	= 0.6322
Root MSE	= .32667

lPCE	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
agehead2	-.0000588	.0000186	-3.17	0.002	-.0000952	-.0000224
agewife	-.0008386	.0008541	-0.98	0.326	-.002513	.0008358
agewife2	-8.51e-07	.0000142	-0.06	0.952	-.0000288	.0000271
_Ischoolhe~1	.0076171	.0250807	0.30	0.761	-.0415509	.0567852
_Ischoolhe~2	.0017446	.0162534	0.11	0.915	-.0301185	.0336076
_Ischoolhe~3	.0043026	.0180312	0.24	0.811	-.0310455	.0396508
_Ischoolhe~4	.0066703	.0244465	0.27	0.785	-.0412545	.0545951
_Ischoolhe~5	-.01367	.0195953	-0.70	0.485	-.0520845	.0247445
_Ischoolhe~6	.023887	.0220672	1.08	0.279	-.0193733	.0671473
alfawife	.0013557	.0096281	0.14	0.888	-.0175191	.0202305
indigenahead	-.0065685	.0286301	-0.23	0.819	-.0626948	.0495577
indigenawife	.01982	.0258743	0.77	0.444	-.0309038	.0705438
medright	.0139579	.005537	2.52	0.012	.0031032	.0248126
missingmed~t	-.0627379	.0215983	-2.90	0.004	-.1050791	-.0203968
missi~shmean	.0634103	.093524	0.68	0.498	-.1199333	.2467539
missingm~ean	.0810057	.0909455	0.89	0.373	-.0972832	.2592945
mathmean	.0130252	.00821	1.59	0.113	-.0030696	.0291199
spanishmean	.0070025	.0085801	0.82	0.414	-.0098179	.0238229
schoolgowife	.0431917	.0418386	1.03	0.302	-.0388283	.1252117
male04	-.092516	.0084881	-10.90	0.000	-.1091561	-.075876
male59	-.0739813	.0081418	-9.09	0.000	-.0899424	-.0580202
male1014	-.0334178	.0079012	-4.23	0.000	-.0489072	-.0179283
male1554	-.0375868	.0060136	-6.25	0.000	-.0493758	-.0257978
male55plus	-.0420716	.0153805	-2.74	0.006	-.0722233	-.0119199
female04	-.0858703	.0088382	-9.72	0.000	-.1031967	-.068544
female59	-.0582954	.0082065	-7.10	0.000	-.0743833	-.0422075
female1014	-.0613197	.0081369	-7.54	0.000	-.0772712	-.0453682
female1554	-.0298994	.0060549	-4.94	0.000	-.0417693	-.0180294
lognonfood	.2949664	.0050755	58.12	0.000	.2850164	.3049163
piso	.0153314	.0129438	1.18	0.236	-.0100435	.0407064
wall	-.027351	.0238703	-1.15	0.252	-.0741462	.0194441
roof	.0013818	.0154592	0.09	0.929	-.0289242	.0316879
_Ikitchens~1	-.0130395	.0127515	-1.02	0.307	-.0380375	.0119585
_Ikitchens~2	-.0254296	.020283	-1.25	0.210	-.0651922	.0143331
serviciosan	.0033003	.0165069	0.20	0.842	-.0290597	.0356604
luz	-.0033829	.0222522	-0.15	0.879	-.0470059	.0402402
refrigerador	.0052446	.0114025	0.46	0.646	-.0171088	.027598
estufa	.0098502	.0126766	0.78	0.437	-.0150009	.0347013
_cons	4.589524	.3376705	13.59	0.000	3.927557	5.25149

B.3 Vitamin A

```
      Source |       SS       df       MS              Number of obs =    5936
-------------+------------------------------           F(256,  5679) =   41.95
       Model |  1186.9635   256  4.63657617            Prob > F      =  0.0000
    Residual | 627.620298  5679  .110515988            R-squared     =  0.6541
-------------+------------------------------           Adj R-squared =  0.6385
       Total |  1814.5838  5935  .305742847            Root MSE      =  .33244

------------------------------------------------------------------------------
        lPCE |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     agehead |   .0057385   .0017826     3.22   0.001      .002244    .0092331
    agehead2 |   -.000067   .0000187    -3.58   0.000    -.0001036   -.0000303
     agewife |  -.0010686   .0008614    -1.24   0.215    -.0027573      .00062
    agewife2 |   3.56e-06   .0000144     0.25   0.804    -.0000246    .0000317
_Ischoolhe~1 |   .0134267   .0251883     0.53   0.594     -.035952    .0628054
_Ischoolhe~2 |   .0031924   .0161887     0.20   0.844    -.0285436    .0349285
_Ischoolhe~3 |   .0095665   .0180192     0.53   0.596     -.025758    .0448909
_Ischoolhe~4 |   .0077491   .0245281     0.32   0.752    -.0403354    .0558336
_Ischoolhe~5 |  -.0082833   .0196276    -0.42   0.673    -.0467609    .0301942
_Ischoolhe~6 |   .0259397   .0221533     1.17   0.242    -.0174891    .0693686
    alfawife |   .0012928   .0096937     0.13   0.894    -.0177105    .0202962
indigenahead |  -.0068231   .0285591    -0.24   0.811    -.0628097    .0491636
indigenawife |   .0068559   .0257942     0.27   0.790    -.0437105    .0574224
    medright |   .0156159    .005563     2.81   0.005     .0047103    .0265214
missingmed~t |  -.0584332   .0218044    -2.68   0.007    -.1011782   -.0156882
missi~shmean |   .0766999   .0946668     0.81   0.418    -.1088831    .2622829
missingm~ean |   .0680921   .0920958     0.74   0.460    -.1124508    .2486349
    mathmean |   .0117236   .0082867     1.41   0.157    -.0045214    .0279687
 spanishmean |   .0083022   .0086701     0.96   0.338    -.0086945    .0252988
schoolgowife |   .0314081   .0419295     0.75   0.454    -.0507897    .1136059
      male04 |  -.0911051   .0085327   -10.68   0.000    -.1078325   -.0743777
      male59 |  -.0751307    .008151    -9.22   0.000    -.0911098   -.0591515
    male1014 |  -.0318604   .0079514    -4.01   0.000    -.0474483   -.0162725
    male1554 |  -.0386793   .0060585    -6.38   0.000    -.0505562   -.0268025
  male55plus |  -.0410226   .0154949    -2.65   0.008    -.0713986   -.0106466
    female04 |  -.0877291   .0088646    -9.90   0.000    -.1051072   -.0703511
    female59 |  -.0578725   .0082229    -7.04   0.000    -.0739925   -.0417524
  female1014 |  -.0617597   .0081397    -7.59   0.000    -.0777166   -.0458028
  female1554 |  -.0292095   .0060908    -4.80   0.000    -.0411498   -.0172691
  lognonfood |   .2942767   .0050638    58.11   0.000     .2843497    .3042037
        piso |   .0132988   .0130144     1.02   0.307    -.0122144     .038812
        wall |  -.0348362   .0239179    -1.46   0.145    -.0817244    .0120521
        roof |     .00524   .0155019     0.34   0.735    -.0251497    .0356296
_Ikitchens~1 |  -.0119707   .0128336    -0.93   0.351    -.0371295     .013188
_Ikitchens~2 |  -.0212149   .0203044    -1.04   0.296    -.0610194    .0185895
 serviciosan |   .0094151   .0166069     0.57   0.571    -.0231407    .0419709
         luz |   .0028939   .0220606     0.13   0.896    -.0403533    .0461412
refrigerador |   .0053249   .0115172     0.46   0.644    -.0172532     .027903
      estufa |   .0173619   .0127993     1.36   0.175    -.0077296    .0424535
       _cons |   4.819243    .246698    19.53   0.000     4.335621    5.302865
------------------------------------------------------------------------------
```

B.4 Iron heme

Source	SS	df	MS
Model	764.892393	256	2.98786091
Residual	413.411108	4460	.092693074
Total	1178.3035	4716	.249852311

Number of obs =	4717
F(256, 4460) =	32.23
Prob > F =	0.0000
R-squared =	0.6491
Adj R-squared =	0.6290
Root MSE =	.30446

lpce	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
agehead	.0037644	.0018637	2.02	0.043	.0001107	.0074181
agehead2	-.0000471	.0000194	-2.43	0.015	-.0000852	-9.10e-06
agewife	3.76e-06	.0008838	0.00	0.997	-.001729	.0017365
agewife2	-.0000148	.0000148	-1.00	0.316	-.0000438	.0000142
_Ischoolhe~1	.0099625	.0265568	0.38	0.708	-.0421019	.062027
_Ischoolhe~2	-.0068433	.017222	-0.40	0.691	-.0406069	.0269203
_Ischoolhe~3	-.0084463	.0190024	-0.44	0.657	-.0457005	.0288079
_Ischoolhe~4	-.0144345	.0255222	-0.57	0.572	-.0644706	.0356016
_Ischoolhe~5	-.0192688	.0203962	-0.94	0.345	-.0592554	.0207178
_Ischoolhe~6	.0106668	.0227062	0.47	0.639	-.0338486	.0551823
alfawife	-.0000926	.0100139	-0.01	0.993	-.0197247	.0195395
indigenahead	-.0128537	.0303138	-0.42	0.672	-.0722838	.0465765
indigenawife	.0247067	.0281903	0.88	0.381	-.0305602	.0799736
medright	.0117918	.00557	2.12	0.034	.0008719	.0227117
missingmed~t	-.0567693	.0216998	-2.62	0.009	-.0993116	-.0142269
missi~shmean	.0748773	.1034401	0.72	0.469	-.1279166	.2776713
missingm~ean	.1066191	.1011481	1.05	0.292	-.0916814	.3049196
mathmean	.0147046	.0084847	1.73	0.083	-.0019296	.0313389
spanishmean	.0094854	.008859	1.07	0.284	-.0078826	.0268535
schoolgowife	.0230833	.0417406	0.55	0.580	-.058749	.1049157
male04	-.1011591	.0088957	-11.37	0.000	-.1185991	-.083719
male59	-.0785885	.0085285	-9.21	0.000	-.0953086	-.0618684
male1014	-.036804	.0082149	-4.48	0.000	-.0529093	-.0206987
male1554	-.0338816	.0062465	-5.42	0.000	-.0461278	-.0216354
male55plus	-.040719	.0159642	-2.55	0.011	-.0720168	-.0094212
female04	-.0852516	.0093134	-9.15	0.000	-.1035105	-.0669927
female59	-.0644733	.0085697	-7.52	0.000	-.081274	-.0476725
female1014	-.0615045	.0084448	-7.28	0.000	-.0780605	-.0449485
female1554	-.0369418	.0062376	-5.92	0.000	-.0491705	-.024713
lognonfood	.2887319	.0054386	53.09	0.000	.2780696	.2993942
piso	.0251808	.0135634	1.86	0.063	-.0014102	.0517718
wall	-.0245393	.0250288	-0.98	0.327	-.0736082	.0245295
roof	.0011549	.0162193	0.07	0.943	-.030643	.0329528
_Ikitchens~1	-.0242449	.0131361	-1.85	0.065	-.0499981	.0015084
_Ikitchens~2	-.0331281	.0217167	-1.53	0.127	-.0757036	.0094475
serviciosan	.0054297	.0173217	0.31	0.754	-.0285294	.0393889
luz	-.0054343	.0238832	-0.23	0.820	-.0522572	.0413887
refrigerador	.0090285	.0117012	0.77	0.440	-.0139117	.0319688
estufa	.0115883	.0131571	0.88	0.378	-.0142062	.0373829
_cons	4.610276	.3171798	14.54	0.000	3.988446	5.232105